co-ordinate kG, or the vertical distance of the centre of gravity of the semi-arch from its base, and by a similar process, the other co-ordinate HG, or the horizontal distance from the axis can be found, for let us suppose that the rectangular plane $DAbE$, revolves about the side DE, which remains fixed, it will by such a revolution generate a cylinder of which the diameter is AB and altitude DE, while the quadrantal plane ACD generates a hemisphere of the same diameter, the difference between these being equal to the solid generated by the revolution of the semi-arch $ACEb$.

Now, by the rules of mensuration, the solidity of the cylinder is $3{\cdot}1416 \times AD^2 \times DE$; and that of the hemisphere is $2{\cdot}0944\ AD^3$; therefore by subtraction, we have $3{\cdot}1416 \times AD^2 \times DE - 2{\cdot}0944\ AD^3 = 2{\cdot}0944\ AD^2\ (1{\cdot}5DE - AD)$; but the area of the figure by which this solid is generated, is, as we have already shewn, expressed by the term $AD\ (DE - {\cdot}7854\ AD)$; therefore, by division, we get

$$\frac{2{\cdot}0944\ AD^2(1{\cdot}5\ DE - AD)}{AD\ (DE - {\cdot}7854\ AD)} = \frac{2{\cdot}0944\ AD\ (1{\cdot}5\ DE - AD)}{(DE - {\cdot}7854\ AD)}$$

This expression represents the circumference of the circle described by the centre of gravity of the semi-arch when revolving about the axis DE; and if this be divided by the constant number 6·2832, we get

$$HG = \frac{AD\ (1{\cdot}5\ DE - AD)}{3\ DE - {\cdot}7854\ AD)};$$

and consequently, by subtraction, iG or kA, the horizontal co-ordinate, becomes

$$kA = AD - HG = AD - \frac{AD\ (1{\cdot}5\ DE - AD}{3\ (DE - {\cdot}7854\ AD}$$

which being reduced to its simplest form, is

$$iG = kA = \frac{AD\ (1{\cdot}5\ DE - 1{\cdot}3562\ AD)}{3\ (DE - {\cdot}7854\ AD)} \quad \ldots\ (C)$$

Let now the value of kG, as given in equation (B), and that of kA, as given in equation (C), be respectively substituted instead of them in equation (A), and we get

$$ef = \sqrt{\frac{2wAf \cdot AD\ (1{\cdot}5\ DE - 1{\cdot}3562\ AD)}{bf\ (1{\cdot}5\ DE^2 - AD^2)}}.$$

Now, the quantity $2w$ in this equation, is equivalent to twice the area of the semi-arch $ACDb = 2\ AD\ (DE - {\cdot}7854\ AD)$; hence, finally we obtain for the thickness of the pier,

$$ef = \sqrt{\frac{2Af \cdot AD^2\ (DE - {\cdot}7854\ AD)\ (1{\cdot}5\ DE - 1{\cdot}3562\ AD)}{bf\ (1{\cdot}5\ DE^2 - AD^2)}} \quad \ldots\ldots\ (D).$$

If this equation be compared with that which is given in the volume where the problem is proposed, it will be found to be much superior, in so far as it involves nothing but given quantities; it is, however, of too complex a form to admit of being intelligibly expressed in words; but if the reader pays due attention to the steps of the process by which the following question is resolved, he will find no difficulty in applying the same principles to any other similar case.

Example 1.—Suppose the arch ACB to be a semi-circle, of which the span or diameter AB is ninety feet, the thickness CE at the crown six feet, and Af the distance from the foundation to the impost at A eighteen feet, what must be the thickness of the pier to sustain the thrust af the arch, the summit of the piers, and the roadway being in the same horizontal plane? The several data as here given, when referred to the parts of the figure as combined in equation (D), may be particularized as follows, viz.:—

Af=18 ft.; AD=45 ft.; DE=45×6=51 ft.; and bf=51+18=69 ft.

From the data as thus assimilated we have the following process:—

$DE - {\cdot}7854\ AD = 51 - {\cdot}7854 \times 45 = 51 - 35{\cdot}343 = 15{\cdot}657$

$1{\cdot}5\ DE - 1{\cdot}3562\ AD = 76{\cdot}5 - 1{\cdot}3562 + 45 = 76{\cdot}5 - 61{\cdot}029 = 15{\cdot}471,$

$2\ Af \times AD^2 = 2 \times 18 \times 45 \times 45 = 36 \times 2025 = 72900;$

Let these three results be multiplied together, and we shall have the numerator of the fraction thus—

$15{\cdot}657 \times 15{\cdot}471 \times 72900 = 24222{\cdot}9447 \times 729 = 17652526{\cdot}6363$ = the numerator,

and $bf\ (1{\cdot}5\ DE^2 - AD^2) = 69 \times (1{\cdot}5 \times 51 + 51 - 45 \times 45) = 129478{\cdot}5$ = the denominator;

then by dividing and extracting the square root, it is

$$ef = \sqrt{\frac{17652526{\cdot}6363}{129478{\cdot}5}} = 11{\cdot}678 \text{ ft., the thickness of the pier sought.}$$

T.

THE STUDY OF DESIGN.

The system of instruction pursued at the Manchester School of Design is said to have been eminently successful; and other similar institutions have applied to the council for advice and assistance in introducing elsewhere the same system. With the view of enabling the council to impart the information sought, and to put them fully in possession of his views on the subject, Mr. George Wallis, the head-master, addressed a letter to the council, which they have published. The following extracts will shew our readers the course which is pursued there, and may be valuable to those who desire to teach themselves:—

"By the rules of the school, every student enters the elementary class; as those who have previously been taught drawing seldom possess a knowledge of the simple principles of linear construction. The first requisite, therefore, is to give them this knowledge, and they commence by the study of right or straight lines—horizontal, perpendicular, and diagonal—drawn in parallels and divided into relative proportions, as 2, 3, 4, 6, equal parts. These are carefully drawn without the aid of any mathematical instrument, by that most useful of drawing implements, the black lead pencil,—the natural action of the hand being explained and illustrated, and a severe method of handling constantly insisted upon throughout the full course. Clearness, distinctness, and precision being the end sought, as without these, intelligence in drawing is impossible. The scratched and slovenly effects so commonly resorted to in the ordinary modes of tuition, cannot, therefore, be too strongly deprecated.

Having attained the power to draw a straight line with precision, and to judge of its only dimension—length; and of distance and proportion, by dividing that length; the student proceeds to the construction of simple angles, and from these to polygonal figures, as the basis of the curve; then to the circle, simple and intersected, which in most cases he draws with almost mathematical accuracy after comparatively few lessons. The spiral, the ellipse, the true oval or egg form, and other variations of the curve, follow; the relation between the angle and the curve being carefully kept before him. This may be said to finish his *free-hand* geometric course.

From this he proceeds to the simplest compositions, first as based on radiation and undulation, then on balance and repetition, as arising out of those principles; the fact being strongly impressed on his mind that, in attaining the knowledge of drawing the right line and the curve, he possesses the elements of all form, and has only to study their judicious combination. It will thus be seen that the course of outline is strictly progressive. By this means a knowledge of composition, even in the most complex examples, is gradually imparted to the student; and he is habituated to analyse form, as well as imitate its more apparent effects."

"This brings us to the class for shading, which has been divided into two sections. Those students to whom a knowledge of the human figure is essential in their future practice, as decorative painters, carvers, general engravers, &c., form the first section, and are taught to shade in chalk, by diagrams of flat tints, and afterwards by exercising them from the lithograph on white, and afterwards on tinted paper; and as a preparation for drawing from the large examples of the ornamental cast, each student executes a drawing enlarged from the copy, as an evidence of his power to judge of proportion, as well as size and form. Regarding this as the best method of teaching crayon drawing, I trust it will be understood that no student is suffered to continue drawing from the flat after he has attained a proper method of using his materials, which the exercise from well-selected examples of the lithograph is best calculated to give him. By this means he forms a mode of treatment of his own, and never falls into *manner*, which is the usual bane of schools and academies. Hitherto *mannerism* has been avoided, through this plan of not keeping the student so long at the lithograph as to make him a mere copyist, or on the other hand taking him to the cast without a knowledge of the method of imitating shadow, which necessarily involves so much teaching and illustration by the instructor, as to cause the pupil insensibly to fall into the master's mode of treatment, instead of working out one for himself.

A few words may here be said as to the best method of teaching the use of chalk in producing shadowed effects. The *stump*, an instrument of the greatest value to the accomplished draughtsman, is as decidedly useless and injurious to the youthful student, whose purpose is to learn to express relief by the imitation of shadow; for it induces him to overlook the fact that he has two effects of form to imitate,—that of outline, as on a plane, and that of relief, as expressed by projection; and that the latter, or perspective of his subject, will be best expressed by well studied lines agreeing with the contour. Experience has proved, therefore, that the crayon alone is the best instrument for education, since few or none who study with the *stump* ever shade well with the crayon point, whilst those who are well practised in the latter method possess the power of working with the former at any time, without those slovenly and dirty effects which in most cases result from its early use. As a means of education, then, the use of the *stump* is very objectionable.

The second section of the class for shading is composed of those students who are already, or may intend to become, designers for calico prints, silks, and other woven materials. These are taught shading by means of Indian ink, in the first instance from the flat, and afterwards from the cast; this method being peculiarly appropriate to their future pursuits, as giving them an early and valuable power over their instrument, the *brush*. I have, however, always desired to impart a knowledge of the human figure to these students, and regarded it as unfortunate that an opinion should prevail that it is useless to them. That it is an obvious absurdity to use the figure, or animals generally, on the materials for which these students are called upon to design, and that such use ought to be discouraged by every man of taste, is quite true: but I hold it essential to the success of this important class, that the figure should be taught them after preliminary instruction in the use of the crayon, and that this should be carried on simultaneously with their study of the history and principles of design; thus making, as far as possible, each course of study subservient to their general knowledge of art, as applicable to the purpose for which they are studying.

It may be asked,—Why teach the figure to the designer for textile fabrics, when you deprecate its use in his designs? My answer is,—Because it would expand his ideas of form, and give him a power of hand which the study of one class of forms, be it what it may, can never do. Hence the fallacy of supposing, on the other hand, that if the student draws the figure well, he can draw any thing, and, according to some authorities, design it too. But, allowing that the power to draw the figure would, in a great measure, qualify the student to draw any object placed before him, it must be borne in mind that the true ornamentist is not a mere copyist, but a reproducer of nature in a new form, and that he takes it rather as a basis for his invention, than as an object for his imitation. Hence the necessity for a very varied course of study, and constant recollection that the power merely to draw one object correctly, however excellent in itself that object may be, does not necessarily involve the power to represent every other object equally well; but I have ever advocated the study of the figure by every class of ornamentists, for the same reason that I believe the study of ornament is valuable to the historic artist, as a means of cultivating his taste, and increasing his knowledge of form and his powers of invention.

It will be thus seen, that I regard the proper and legitimate use of the figure—as the highest type of natural form, of the greatest possible value; but not as an elementary study, inasmuch as the necessity exists of first giving the student the power to apprehend and delineate form from less complex objects; those, in short, which he can most readily understand. For, as before stated, to imitate forms correctly and with intelligence, requires something more than the mere mechanical process of combining lines; in truth, the student must be taught to analyse the form before him, and this power should be given him at the outset."

"The student being thoroughly educated to draw any object placed before him in outline, and to represent its light and shadow by means